SHOREBIRD HABITAT USE, IMPACTS OF HABITAT TRANSFORMATION, AND SURVEY TECHNIQUES

A LITERATURE REVIEW AND STUDY DESIGN

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The estuary of Grays Harbor has been identified as one of the most important shorebird concentration areas on the Pacific Coast of North America (Herman and Bulger 1981, Brown *et al.* 2001). Upward of over 1 million shorebirds stage on the intertidal flats of this estuary during a few weeks in spring. Most species using the site in spring are returning from wintering areas on the Pacific Coast as far south as Argentina and as far north as Oregon. A few species move into the area from wintering sites in the Caribbean. These birds are migrating northward to breeding areas in boreal and arctic regions of Canada and Alaska. A few species [such as spotted sandpipers (*Actitis macularia*) and killdeers (*Charadrius vociferus*)] breed along the shores of Grays Harbor but most of the vast numbers of spring migrants continue north. Fall migration for shorebirds is a less spectacular event, and can occur from late June when non-nesting and failed-nesting adult sandpipers begin to move southward, through late October when northern-wintering species such as dunlin (*Calidris alpina*) finally arrive from Alaska and Canada. Use of Grays Harbor during fall migration may involve only a few thousand birds at any given point in time. During winter (October through March), up to 100,000 shorebirds, mostly dunlin and black-bellied plovers (*Pluvialis squatarola*), feed in the estuary and roost on adjacent beaches and shorelines (Brennan et al. 1985, Buchanan 1992, Paulson 1993, Morse et al. 2001).

Long-term studies of shorebird populations in Europe and the eastern United States have indicated that populations of many species have been declining (Moser 1987, Howe et al. 1989). More than half of the U.S. human population lives within 80 km of either coast, putting pressure on coastal environments (Bildstein *et al.* 1991). The estuarine and beach habitats used by migrating and wintering shorebirds on both coasts of the lower 48 states are often of economic importance as fish and shellfish habitat, recreation, and for interstate commerce. Important shorebird habitat has been compromised in the past due to dredging, filling, pollution, and disturbance. Therefore, major construction operations that could affect shorebird habitat in large estuaries of the U.S. will often draw attention from local environmental organizations because of their potential effects on shorebirds and other estuarine resources.

At Grays Harbor, recent high tide and storm events have caused temporary breaching of the land connection between the South Jetty and its adjacent peninsula near Westport, Washington. Short-term and long-term solutions to repair this breach and maintain the effectiveness of the jetty system at the mouth of this bay will involve placement of fill and replanting of dune grasses and possible revetment of the base of the jetty. These operations have been identified as being of possible consequence to shorebirds using the local area. The purpose of this literature review is to identify the important sources of information on habitat use of shorebirds in the region and the effects of transformations of shorebird habitat. Attention is also paid to techniques used to monitor shorebirds in areas of habitat transformation. In relation to this review, a study design is presented to investigate the general use patterns of the project site at Point Chehalis by shorebirds and other birds, and potentially as a monitoring plan for the long-term maintenance of the jetty and navigation channel.

2.0 LITERATURE REVIEW

2.1 SHOREBIRD STUDIES IN COASTAL REGIONS OF THE PACIFIC NORTHWEST

As a group, shorebirds have received relatively little scientific study in the Pacific Northwest (Buchanan 2000). Reasons for this are many, but include the fact that few shorebirds are listed as endangered or threatened, they are mostly non-game species, and therefore relatively little money is available for study in areas with few immediate threats to habitat. Popular literature on this bird group such as species identification, viewing areas, and conservation concerns are well known and readily available, but scientific literature on habitat use and particularly on effects of habitat transformation and disturbance are limited. Below is a review of available literature on habitat use during the migration and wintering period in areas that are close to or similar in nature to the South Jetty project site in Grays Harbor. Studies that have addressed impacts on habitat for shorebirds in the region or in similar regions around the world are also reviewed. Finally, a section discussing survey methods used during habitat use and impact studies are also reviewed.

2.1.1 Shorebird Habitat Use

Over thirty species of shorebirds regularly use the various habitats (tidal sand flats and mud flats, oceanic beaches, rocky headlands, protected bay shores, salt marshes, freshwater marshes, fields, dunes, etc.) found in and near the Grays Harbor estuary (Herman and Bulger 1981, Paulson 1993). In estuary situations such as this, the greatest numbers of shorebirds are found on intertidal flats feeding on invertebrate prey captured on or within alluvial substrates. Feeding techniques, habitat use, and major prey items vary between species, however. Some habitat use patterns are quite subtle (Quammen 1982), for example, western sandpipers (*Calidris mauri*) may appear to feed and roost along side dunlin in the same habitat, but are found to occupy slightly shallower feeding sites at the edge of the tide line, and often roost slightly higher on sloping beaches or salt marshes than their congener (Wilson 1993).

Estuaries – Winter. Most of the shorebirds wintering in Grays Harbor use mudflats for feeding and nearby islands, beaches and salt marshes for roosting (Kalinowski et al. 1982, Buchanan 1992). While only 20,000 shorebirds regularly wintered in Grays Harbor in the early 1980's (Brennan et al. 1985), this number has either grown or, through more thorough surveying, is now known to be over 100,000 shorebirds, according to recent Audubon Christmas bird count data (B. Morse, pers. comm.). Shorebird flocks developed regular roost sites and movement corridors, avoiding areas of intense human disturbance (Kalinowski et al. 1982). During high tide they preferred to roost at sites away from inundation at the highest high tides but choose sites within open habitats where approaching predators could be detected. Sand islands within the estuary, protected shorelines, salt marshes, flooded fields, and ocean beaches provided roost habitat. These same authors reported that wintering dunlin fed largely on amphipods and a species of burrowing isopod, while western sandpipers (*Calidris mauri*) are known to feed largely on annelid worms (also Couch 1966). These authors also noted that feeding sites were more likely to be near regular movement pathways used by flocks of sandpipers to cross

the estuary, than at sites distant from movement corridors. Recent studies have shown that prey depletion in regularly used sites causes shorebirds to shift to new areas and requires time for resettlement of larval prey species in depleted areas (Wilson 1991).

In other Pacific coast estuaries, wintering shorebirds on San Francisco Bay have received some study (Holway 1990, Warnock and Takekawa 1995). Here, timing and movements of sandpiper flocks from feeding areas on mudflats to roosting areas on nearby levees has been well documented. Western sandpipers in San Francisco Bay, like dunlins in Washington, moved daily from feeding areas on tidal mud flats during low tide to artificial salt ponds and levees for roosting at high tide (Warnock and Takekawa 1995). At Bolinas Lagoon, habitat use patterns of wintering shorebirds were also studied and mirrored substrate type use patterns seen in Grays Harbor (Page *et al.* 1979). In the Mad River estuary in northern California, studies on shorebirds found that feeding distribution was correlated not only with substrate types, but also densities of food organisms (Colwell 1993, Colwell and Landrum 1993). In Alaska, dunlins were studied at roost sites prior to fall migration, and there they also foraged on mud flats and roosted in salt marsh and open beaches adjacent to feeding sites (Handel and Gill 1992).

Estuaries – Spring. Spring migration in the Grays Harbor estuary was notably documented by Herman and Bulger (1981), Kalinowski *et al.* (1982), and Wilson (1993). Upward of 1 million shorebirds pass through the estuary annually. Again, the intertidal mud and sand flats hosted the heaviest concentrations of shorebirds, with some use of adjacent rocky shores and jetties and sandy outer beaches adjacent to the open Pacific Ocean. Spring migration began by 10 April, was most concentrated from 23-24 April, and lasted through mid-May. Timing of shorebird migration in recent years can sometimes occur up to a week earlier (Morse et al. 2001). Shorebirds feeding on the intertidal mud flats of the estuary will roost in large numbers at a few sites, such as the salt marshes of Bowerman Basin where counting is often done (U.S. Fish and Wildlife Service, unpubl. data). Nearby Willapa Bay is also used as a feeding and roosting site for migrating shorebirds (Kyte and Jordan 1985) but to a lesser extent than Grays Harbor. This estuary receives less flushing from the smaller rivers feeding into it, which may affect the productivity of tidal flats. The most common species of shorebirds at Grays Harbor in spring (dunlin and western sandpipers) feed largely on amphipods in the genus *Corophium* (Wilson 1994, Warnock and Gill 1996).

Sandy Beaches. The primary shorebird species during migration and winter occupying coastal beaches as feeding habitat are the sanderling (*Calidris alba*) and black-bellied plover. The sanderling feeds largely in the surf zone on hippid crabs, isopods, amphipods, and other crustaceans (Connors et al. 1981, MacWhirter et al. 2002). Foraging flocks are a frequent sight on Washington beaches during fall, winter, and spring. Black-bellied plovers feed primarily in the outer portions of the Grays Harbor estuary during migration and in winter, and spend most of their time on the seaward, sandier tide flats (Herman and Bulger 1981). Black bellied-plovers feed on small clams, amphipods and other small crustaceans taken near the sand surface (Paulson 1995).

Rocky Beaches. Shorebird use of rocky beach habitats is well known but also limited in scientific study. Rocky shorelines of the Pacific northwest host species such as black oystercatchers (*Haematopus bachmani*), ruddy and black turnstones (*Arenaria interpres* and *A. melanocephala*), surfbirds (*Aphriza virgata*), rock sandpipers (*Calidris ptilocnemis*), and wandering tattlers (*Heteroscelus incanus*), which are specific to this habitat and are rarely found away from it. These species feed largely on encrusted mussels, limpets, chitons, and barnacles, as well as other worms and crustaceans (Andres and Falxa 1995, Senner and McCaffery 1997, Nettleship 2000). The larger oystercatchers feed on the larger mollusks on boulders and cobble (Hartwick 1976) while turnstones and surfbirds typically feed on juvenile mussels and barnacles which have established themselves on bare rock patches caused by logs rubbing against the shore during storms (Marsh 1986). Rock sandpipers and tattlers are thought to feed on even smaller prey such as small polychaete worms, juvenile crabs, amphipods, and other crustaceans temporarily caught up in mussel beds and algal mats during low tide (Paulson 1993).

Salt Marshes. Relatively few shorebird species actually feed in salt marsh habitat on the Pacific coast of the U.S. Notable among these are Wilson's snipe (*Gallinago delicata*) and least sandpipers (*Calidris minutilla*; Kalinowski *et al.* 1982). Many species that feed on adjacent mud flats will often roost in this habitat because it provides refuge from all but the highest tides, and the low-growing plants provide some cover but also allow the birds to view aerial predators (Connors *et al.* 1981, Brennan *et al.* 1985). When salt marshes are not available, shorebirds feeding on mud flats will often use adjacent sand islands or ocean beaches for roosting as well. The dense, more inland portions of salt marshes also provide important habitat for avian species other than shorebirds.

Dunes. While rarely used by migrating or wintering shorebirds, sand dunes occurring adjacent to high-energy ocean beaches in western Washington do provide nesting habitat for the locally threatened snowy plover (*Charadrius alexandrinus*). This species requires remote dunes free from frequent use by vehicles, humans, and their pets and adjacent open sand beaches for feeding.
Dunes are occasionally used by roosting shorebirds as well, during very high tides when all exposed shorelines and salt marshes are inundated. As with salt marshes, the higher, more stable vegetation portions of sand dunes are important habitat for passerine bird species which nest in the grass and shrub communities.

2.2 Effects of Habitat Transformation on Shorebirds

With relatively few studies having been done on actual shorebird habitat use in the area, even fewer studies are available that address the effects of habitat transformation. There are abundant data on the effects of habitat loss and disturbance to breeding shorebirds on arctic tundra habitats, mostly around the oil fields at Prudhoe Bay, Alaska (D. Troy, pers comm.). However, effects of habitat transformation on temperate estuarine habitats is limited. [One study that addressed use of restored intertidal habitats in northern California (Wilcox 1986) was unavailable for review].

2.2.1 Studies and Concerns in the Pacific Northwest

Both Connors *et al.* (1981) and Brennan *et al.* (1985), who studied the daily use of feeding sites and roost habitat by estuarine shorebirds on the Pacific Coast, stated that loss of either of these spatially separate habitats (through habitat alteration or disturbance) could result in effective abandonment of the entire area as useful habitat. While productive mud flats used by feeding shorebirds do not occur immediately adjacent to the South Jetty project site, regularly used shorebird feeding habitat is approximately two miles away, at Westport Flat on the east side of the Westport Peninsula (Herman and Bulger 1981). It is likely that shorebirds using this area for feeding may move to the adjacent ocean beach for roosting, including the Point Chehalis area.

Although a given stretch of beach may appear to be heavily used by shorebirds as a roosting or feeding site, nearby escape habitat may also be important. A major predator of shorebirds while at Grays Harbor is the peregrine falcon (*Falco peregrinus*). This species makes regular and often spectacular raids on roosting flocks of dunlins and other shorebirds, moving the flocks along miles of ocean beach or from one salt marsh to another (Page and Whitacre 1975). Availability of not only one beach or island for roosting, but several may be important as a predator avoidance strategy. Also, over-utilization of prey in heavily used habitats may lead to lower recruitment of prey, forcing shorebirds to seek new feeding areas over time (Marsh 1986, Wilson 1991). Recent banding studies have shown that some wintering shorebird species show high site fidelity from year to year (e.g., sanderlings; Myers *et al.* 1986) while others may move gradually southward along the coast of North America as winter progresses, presumably seeking new feeding areas as more northerly sites become depleted (C.T. Schick, pers. comm.).

In rocky habitats, construction of shoreline habitat such as jetties and artificial islands has had some success in use by shorebirds, but may require time to develop healthy adherent communities of mollusks before regular use for feeding is attained (Burton *et al.* 1996). Even given the construction of an artificial island for shorebird use, shorebird numbers in the local area of the above report declined during the post-construction period. In California, kelp restoration in waters adjacent to rocky beach habitat was shown to increase use by wintering shorebirds, particularly by both turnstone species (Bradley and Bradley 1993).

There is concern that invasion of Pacific salt marshes by the relatively tall, dense grass *Spartina*, may negatively affect the feeding and roosting strategies of some shorebirds in coastal Washington (Buchanan 2000). This grass, native to eastern North America, was first introduced from packing material used to ship seed oysters to the Pacific States. *Spartina* has established itself on the Pacific Coast and tends to form dense patches that trap sediment, altering the makeup of tidal flats and salt marshes in areas where it overtakes native salt marsh plants (Frenkel and Kunze 1984).

2.2.2 Other Regional Studies

Impact studies of shorebirds in similar habitats in other parts of the world have concentrated primarily on habitat loss. In Holland, diking and draining of an intertidal flat

and its effects on shorebirds was documented (Lambeck *et al.* 1989). For the species in which census data could be used, the Eurasian oystercatcher (*Haematopus ostralegus*) was shown to have been displaced and densities on adjacent estuaries increased in the years immediately following habitat removal. In central England, conversion of intertidal habitat to a freshwater reservoir was also suspected of forcing oystercatchers to forage in a smaller area, increasing competition for food and affecting body condition and perhaps survival (Goss-Custard 1977). Also in England, gradual drawdown of coastal impoundments created continuous shorebird habitat, however eventual reflooding needed to occur months in advance of shorebird migration to allow for re-establishment of benthic fauna (Rehfisch 1994). In northern England, a deteriorated pier and jetty was replaced with a new structure including a marina, and an artificial island was constructed specifically for shorebird roost habitat (Burton *et al.* 1996). Shorebird numbers declined slightly following construction due mainly to human and other mammal disturbance of roosting flocks on the now-land-connected jetty and boat disturbance of shorebirds on the artificial island. In all cases, impacts on numbers of shorebirds using affected habitats was difficult to document empirically, given the wide variation in inter-annual abundance of shorebirds at any given site and the overall decline or increase in regional populations over time (Lambeck *et al.* 1989, Burton *et al.* 1996).

Disturbance has also been shown to affect shorebird use of habitats in the northeastern U.S. (Burger 1981, 1986; Pfister *et al.* 1992). This type of habitat alteration occurs when popular recreation sites overlap with shorebird habitats, such as on sandy ocean beaches and certain lakeshores. Shorebirds have been shown to be particularly affected by human presence, both at roost sites (Burger 1981) and at feeding areas (Burger 1986, Roberts and Evans 1993, Klein *et al.* 1995). Slowly walking people, slow-moving vehicles, and people clamming had a lesser effect on shorebirds than joggers, dogs, and rapidly moving vehicles. Sanderlings on sandy ocean beaches may even switch to foraging at night in areas of heavy human disturbance (Burger and Gochfeld 1991). Habitats at the South Jetty project site are known to sustain frequent human disturbance, including all of the examples listed above.

2.3 SURVEY TECHNIQUES

Counting shorebirds and other coastal bird species and documenting habitat use has been accomplished using several methods. Each method has its benefits and drawbacks, however consideration should be given to specifics of site configuration, study goals, and eventual use of the data generated in choosing a survey method. For all methods, certain temporal considerations were commonly expressed by researchers. Time of day has been shown to influence numbers of birds observed during surveys such as point counts (Shields 1977, Palmeirim and Rabaça 1994). Statistical techniques (such as running averages) are available to compensate for some of these time effects. The portion of a given season sampled may also affect shorebird counts, particularly in migratory stop-over sites where birds may move through in relatively rapid pulses (Pfister *et al.* 1992). Additionally, the importance of multiple counts of coastal shorebird flocks was emphasized by Colwell and Cooper 1993. They found that several point counts during different tide stages provided a better estimator of general shorebird abundance and usage of estuaries than did one count per day or only a few counts per week. Pfister et al. (1992)

also mentioned that more frequent counts during intense migratory periods (but separated by average length-of-stay for shorebirds) would improve censuses, avoid lack of independence of counts, and prevent double-counting as birds move throughout the site.

A short summary of the most common methods encountered in shorebird habitat use and impact studies is provided in the following paragraphs.

2.3.1 Point Counts/Station Counts

Since the early 1970's, the International Shorebird Survey (ISS) program has conducted annual shorebird surveys at specific observation points across the eastern U.S. Sections of coastal bays or shorelines (and inland marshes and other habitats) were first surveyed during peak use times to identify important shorebird concentrations, and then permanent observation posts are located and counts done from these posts to estimate bird numbers in the area. The program is managed by the Manomet Bird Observatory and relies on large numbers of volunteers, similar to the Breeding Bird Survey (BBS), which conducts roadside surveys of songbirds on an annual basis throughout the U.S. Information on shorebird population trends has been produced by the ISS program and published in the scientific literature (e.g., Howe *et al.* 1989). Recently, the Western Shorebird Survey (WSS) was initiated by the USGS-Biological Services Division to conduct similar surveys in the western U.S. Two observation stations are located in Grays Harbor, one in the eastern portion of the bay and one in the northern portion.

Point Counts have been used in many other shorebird studies, including investigations of impacts to shorebird concentration areas. Examples include habitat alteration at shorebird wintering sites (Goss-Custard 1977, Lambeck *et al.* 1989, Burton *et al.* 1996), and locally, station counts at proposed landfill sites were done along the south and east shore of Grays Harbor by Kalinowski *et al.* (1982). The British Columbia Ministry of Lands and Parks has established standardized survey methods for shorebirds in their province (Ministry of Lands and Parks 1997). Techniques vary depending on season and habitats involved but rely on point counts from prominent outposts of land for migrating and wintering birds. This is probably the most common method used in the very open habitats used by shorebirds. It is most effective when there is an elevated observation post available that has a clear view of all habitats of interest.

2.3.2 Transects

Transects designed to sample and monitor shorebird use of an area and to determine effects of disturbance have also been used. Transects using vehicles driving along beaches or observers walking shorelines is an example of this technique (Pfister et al. 1992, Buchanan 1992) and is effective in areas of limited viewing and is useful where shorebird flocks are accustomed to vehicle or human traffic. Belt transects to survey for breeding shorebirds have also been used, often dragging a rope to flush nesting birds (Mickelson et al. 1980). The transect technique has an advantage over station counts in areas where the entire habitat is not visible from one location. The British Columbia Ministry of Lands and Parks (Ministry of Lands and Parks 1997) state that "The transect method is more suitable [than point counts]for sampling a mosaic of habitats over larger areas."

2.3.3 Censuses

Complete censuses of an area have also been attempted in shorebird studies. Counts of entire estuary systems are occasionally done to estimate populations. Problems with this technique include movements of birds during the census period (either in or out of the census area or within the census area as the observer changes locations), and the time and expense of conducting a census over a large area. Herman and Bulger (1981) attempted complete censuses of Grays Harbor during the spring shorebird migration by using several observers at key points in the estuary, all counting at the same time to avoid movement of birds between census blocks.

For small sites, a complete census may be achieved, often from one observation post or a short transect. Examples of censuses include the Christmas Bird Count which sends out a host of volunteers to cover a large area over a 24-hour period. A complete census of roosting flocks of shorebirds at known use areas was done in Holland prior to enclosure and drainage of an isolated intertidal polder (Lambeck *et al.* 1989).

2.3.4 Aerial Surveys

Aerial surveys by plane or helicopter can also be effective for counting shorebird flocks over large areas (e.g., Kalinowski *et al.* 1981, Handel and Gill 1992). This technique has some limitations, particularly in that species identification is difficult to impossible for most shorebird species, and is essentially only cost effective when large areas need to be covered over a short time span. Errors in observer estimates are often high because of the limited time available to estimate flock sizes.

3.0 STUDY DESIGN: BIRD SURVEYS ASSOCIATED WITH MAINTENANCE OF THE GRAYS HARBOR SOUTH JETTY

3.1 PURPOSE AND NEED

The U.S. Army Corps of Engineers, Seattle District is developing a long-term strategy for the maintenance of the Grays Harbor South Jetty and entrance reach of the navigation channel, including Half Moon Bay (Figure 1). Recent storms have nearly caused a breach of the sand spit connecting the South Jetty with the mainland northwest of the town of Westport, Washington. This has occurred in the southwest corner of Half Moon Bay just north of the Westhaven State Park parking lot and restroom building. Maintenance (dredging) of the entrance reach to Grays Harbor is also anticipated. Because intertidal flats within Grays Harbor are known concentration areas for large flocks of migrating shorebirds, and sandy beach and rocky intertidal habitats are known use areas for shorebirds and seabirds (particularly during the non-breeding period), there is concern for disturbance or habitat displacement of these birds during the proposed maintenance operations. For these reasons, a survey and/or monitoring design is needed to identify the bird species using the area of concern and their timing of use in the habitats to be affected by maintenance operations.

3.2 DESIGN CONSIDERATIONS

3.2.1 Habitat

Four major habitat types occur within the project area that may receive differential use by birds. These habitats include: 1) Rocky Shore and intertidal habitat (man-made) consisting of the South Jetty of Grays Harbor, 2) High-energy Ocean Beach and intertidal habitat south of the South Jetty bordering the Pacific Ocean, 3) Protected Bay Shore and intertidal habitat within Half Moon Bay, east of the South Jetty extending to the Westport marina, and 4) Vegetated Dune and Interdunal Wetland habitat southeast of the base of the South Jetty bordered by the beach habitats mentioned above, and the town of Westport. (Some unvegetated dune habitat also occurs, but is small in extent and heavily used by people so it is unlikely to maintain a unique bird fauna.) Different bird species are likely to be found in each habitat. The Rocky Shore may harbor shorebird species such as black turnstones (*Arenaria melanocephala*), surfbirds (*Aphriza virgata*) and rock sandpipers (*Calidris ptilocnemis*) that will rarely, if ever, use adjacent habitat types. The Bay Shore, with its protected beach, may be more attractive to killdeers (*Charadrius vociferus*), semipalmated plovers (*C. semipalmatus*), and 'peeps' [such as western sandpipers (*C. mauri*)] than would be the Ocean Beach, a habitat occupied by sanderlings (*Calidris alba*) and larger shorebirds such as whimbrels (*Numenius phaeopus*) and godwits (*Limosa* spp.). Dune habitats may harbor resting flocks of gulls, terns and shorebirds and provide needed refuge sites for migrating passerines flying along the coast Flocks of phalaropes are also known to rest on interdunal swales during migration. Sampling each habitat type would sample a different set of avifauna found in the area.

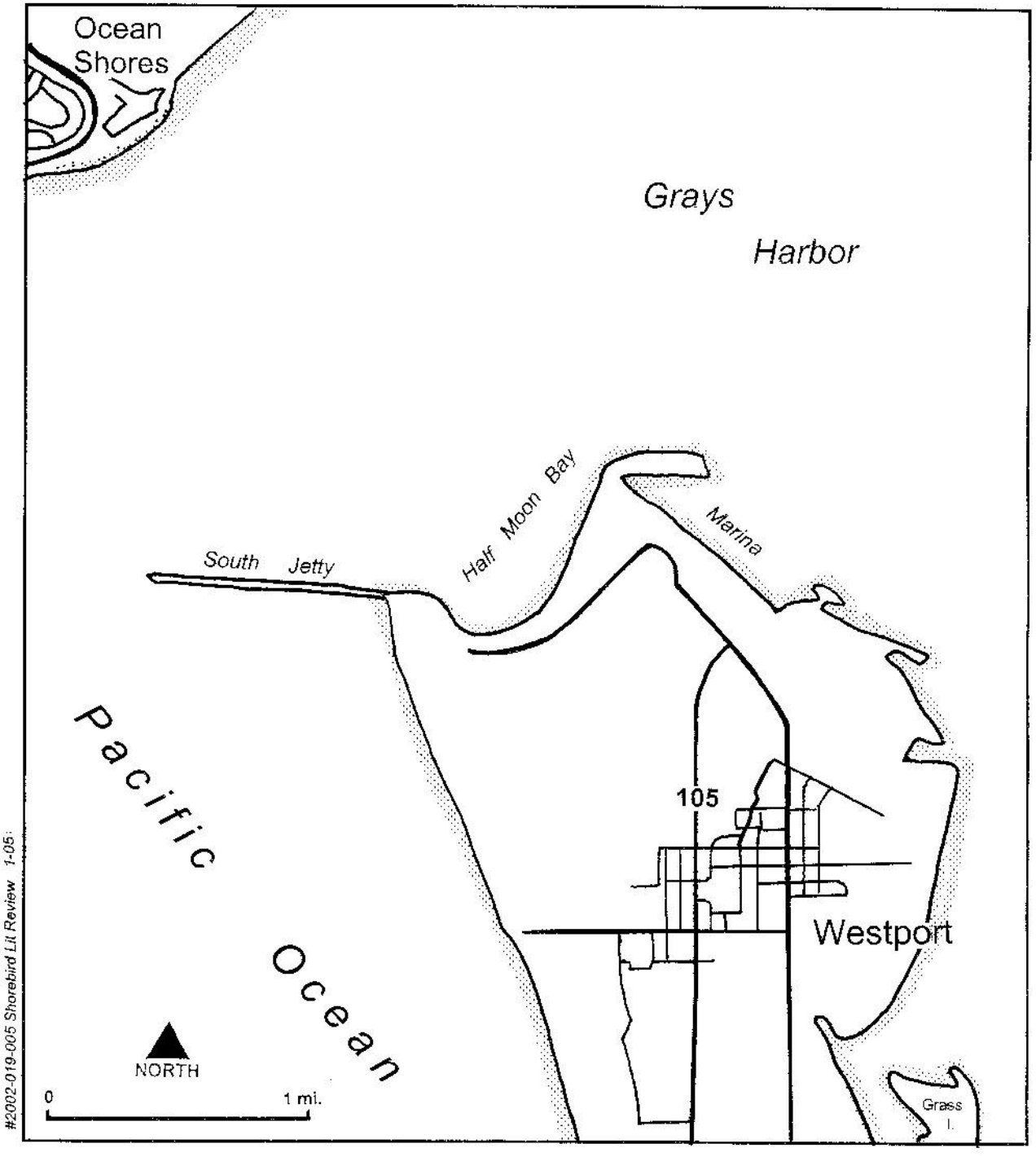

Figure 1. Grays Harbor South Jetty study site and surrounding area (Grays Harbor County, Washington).

3.2.2 Survey Protocols

Established protocols to survey for the wide variety of birds potentially using these habitat types have not been standardized to date (G. Slater, Ecostudies Institute, Mount Vernon, WA., pers. comm.). Since the early 1970's, the International Shorebird Survey has operated survey sites in the eastern United States, generally consisting of set observation points from which observers count shorebirds using the area within view. Observation points are located in areas of heavy shorebird use and are not designed to sample a wide variety of habitats. In general, all surveys should be designed to estimate bird abundance by area (or distance for linear habitats such as beaches) and provide a 'snapshot' of numbers occupying the area for a given time. Otherwise, survey techniques vary by project and by goals. Therefore, a 'one survey fits all' is not available or necessarily desirable for each project. The importance of multiple counts has been emphasized for shorebird surveys due to seasonality and tidal considerations discussed below. Surveys surrounding impact sites generally concentrate on the affected area and describe general use of the site over time. Occasionally, similar habitats in the general area are also sampled as a control, particularly if impacts involve eventual removal of habitat (D. Troy, Troy Environmental, Anchorage, AK., pers. comm.).

3.2.3 Seasonality

Because use will occur across all seasons and may vary depending on the particular season, surveys should be conducted at regular intervals throughout the year. Human disturbance is high in the area, considering the public access associated with Westhaven and Westport Light State Parks and the proximity of the town of Westport and its marina. However, all habitats may provide some limited breeding sites for birds and are likely to be used by migrating and non-breeding birds as foraging and resting sites. For example, pigeon guillemots (*Cepphus columba*) may nest in crevices of rocks on large jetties such as the Grays Harbor jetties, killdeer may nest near protected shoreline habitats, and ground or shrub-nesting passerines such as savannah sparrows (*Passerculus sandwichensis*), white-crowned sparrows (*Zonotrichia leucophrys*), and spotted towhees (*Pipilo maculatus*) may nest in vegetated dunes, even where there is frequent human disturbance. Although large flocks of arctic-nesting shorebirds are known to use the intertidal habitats within Grays Harbor primarily as a spring staging area, smaller numbers may use intertidal habitats in fall and at all times of the year and in different ways. Wintering shorebirds on the Pacific coast of the United States, such as dunlin (*Calidris alpina*) and sanderlings, are known to gradually shift wintering sites as the non-breeding season advances, moving southward as weather cools in the fall, then moving northward as spring approaches. Therefore, numbers of shorebirds may fluctuate monthly at any given site. Gulls and locally-breeding shorebirds may forage in all habitats within the study site at low densities and throughout the year.

3.2.4 Tide Levels

Bird use of three of the four habitat types in the project vicinity may also be influenced by tidal fluctuations (Ocean Beach, Bay Shore, and Rocky Shore). Surveys should be scheduled to cover at least a representative sample of tidal levels, particularly low tide, mid-tide, and high tide situations. Sampling outgoing mid-tidal levels and incoming mid-

tidal levels could also be achieved, given available resources, and sampling at least some high-high tides and low-low tides may also be important.

3.2.5 Time of Day

Particularly in areas close to marine habitats, flocking birds such as gulls, terns, and shorebirds often use beach, shore, or dune habitats as roosting sites and also foraging areas. Varying the time of day that surveys are done would ensure the surveys capture these necessary daily events. Sampling during each of the tide stages (during daylight hours) over one 24-hour period would also ensure that time of day varied across surveys. Surveys should be scheduled to vary the time of day and tide levels so that a representative sample of these periods occurs across the season.

3.3 STUDY DESIGN

3.3.1 Technique

Considering the above factors, the proposed study design for bird monitoring at the Grays Harbor South Jetty project would involve a series of four one-mile (approx. 3-km) transects, one in each of the four major habitat types on the study site. Figure 2 illustrates the approximate location of the transects. Transects could be paced during the first survey and local landscape features used to mark beginning and end of each transect. Qualified observers would walk along the edge of beach and shore transects in areas that would cause the least amount of disturbance to birds using these habitats. Numbers and species of birds would be recorded as the observer walks each transect. In each habitat type, the observer would record bird use in the entire type within view. In most cases, this would provide 100% sampling of the entire mile of habitat. The transect would be walked in a steady manner to try to capture a 'snapshot' of bird use in the mile of habitat.

In the dune habitat, some birds may be missed because of the broad extent of habitat between the city of Westport and the ocean beach. This habitat type is probably least vulnerable to disturbance by the project because of the already high levels of human use and the distance to the project site. A transect through dune habitat, however, would provide the additional benefit of facilitating an easy survey route [beginning at the Westhaven State Park parking lot, surveying the Ocean Beach or Bay Shore transect, cross to the other bay or shore transect via the Dune transect, and then survey the jetty (Rocky Shore habitat) in the outbound direction only].

The observer could avoid disturbance to bird flocks by using nearby roads and trails; however, birds are likely to be flushed from the jetty during surveys (most may simply move to another part of the jetty, but it would be important to walk on this structure due to the ability of shorebird flocks to blend in easily with the jumbled rocks that make up the jetty). By not surveying to the very end of the jetty (but observing the entire jetty with binoculars), the tip of the jetty would then provide a refuge for flushed shorebirds, gulls, and other seabirds.

An additional set of survey transects are proposed for the Ocean Shores peninsula (Figure 3) to document use of similar habitats in the area. These transects provide a sample of

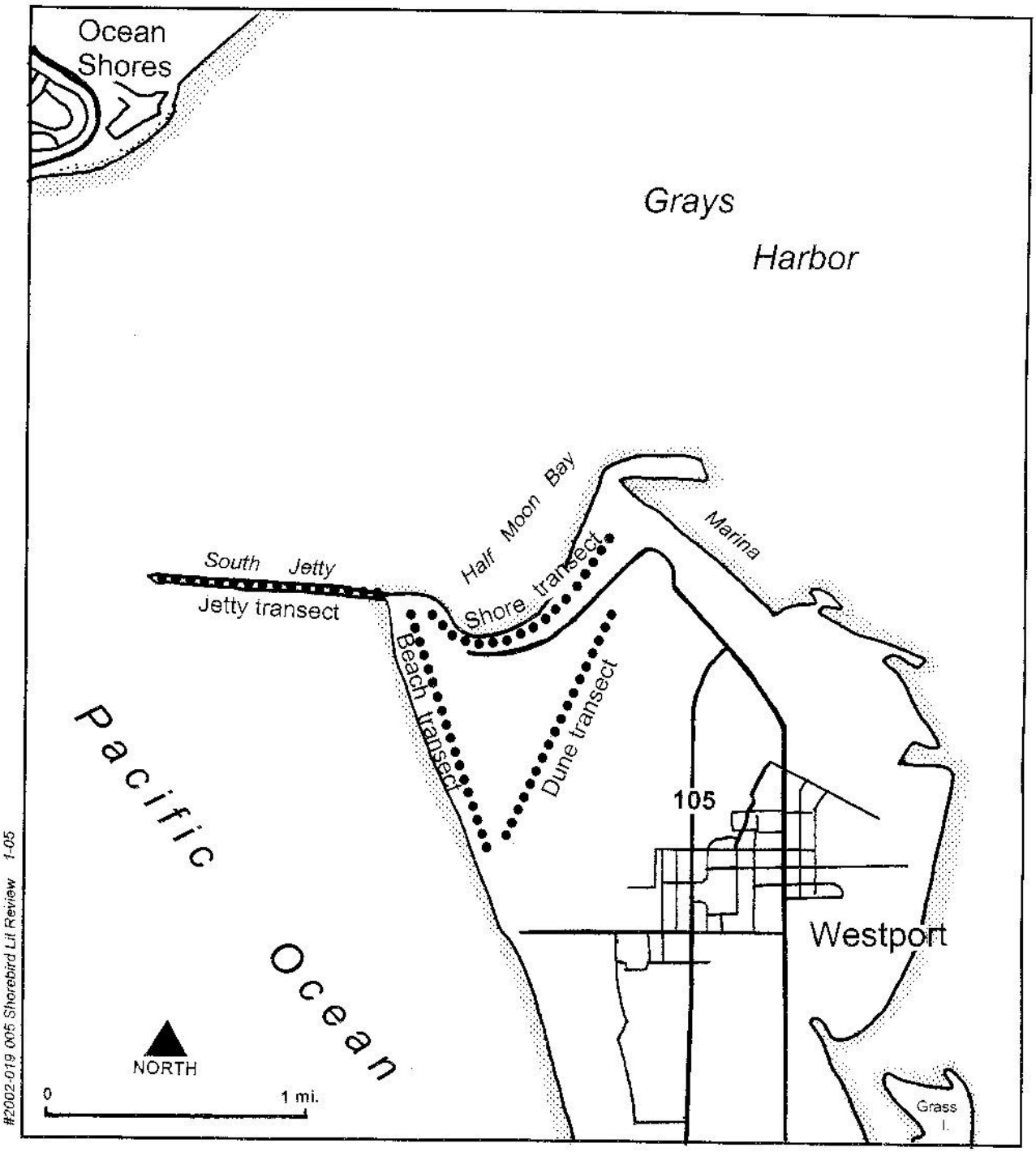

Figure 2. Proposed bird survey transects in the vicinity of the Grays Harbor South Jetty project site.

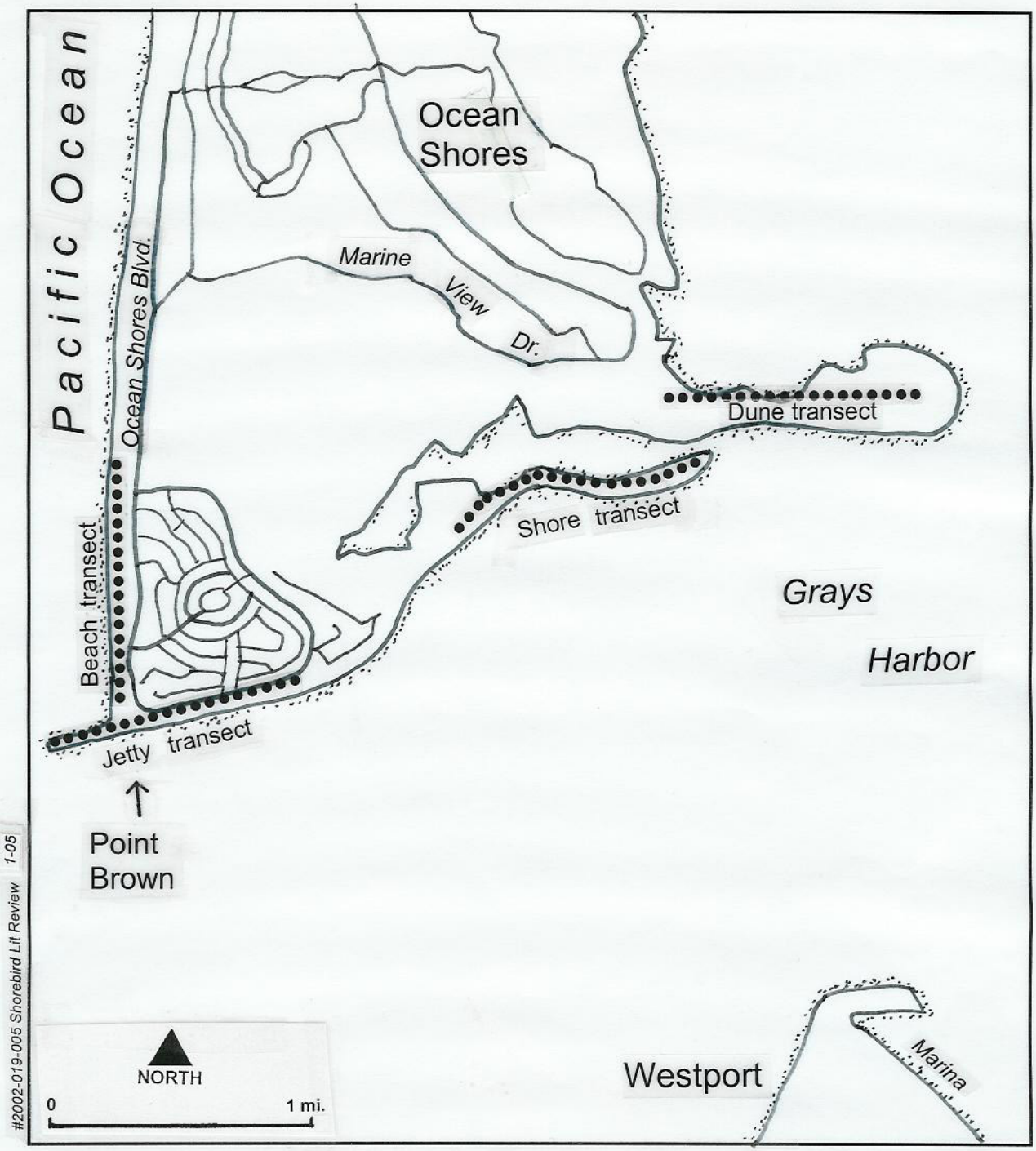

Figure 3. Proposed bird survey transects in the Ocean Shores area (habitats similar to those at the Grays Harbor South Jetty project site).

habitats very similar to the project site and proximate, being directly across the mouth of Grays Harbor from the project. Sampling at these transects may be important to document pre-construction use of the site by birds, and useful during the construction phase to document any displacement of birds from the project site to nearby habitats.

3.3.2 Scheduling

Recommended survey scheduling would be to survey the four transects three times in one day, covering three tidal levels (low tide, mid-tide, and high tide). Surveys would begin when the earliest tide level to be sampled occurs during the day, proceeding through a tide cycle as the day progresses. Surveys should be done in each month of the year, if possible. One or two surveys per month should provide a representative sample of the nature of bird use throughout the year. During peak shorebird migration periods in the spring (mid-April to mid-May), additional survey days are recommended to document any use during this critical period of shorebird abundance in Grays Harbor. At other times of the year when shorebird use (in particular) is expected to be low (e.g., early and mid-summer), fewer surveys may be necessary.

3.3.3 Options Analysis

The number of surveys per year could be adjusted up or down depending on funding levels for the project; however, a representative sample for each season should be maintained. Table 1 summarizes a series of options for proposed bird surveys in the area.

Table 1. Options analysis for bird surveys at the Grays Harbor South Jetty project site.

Option	No. Surveys/Year	Timing/Location	Rationale
1	10	Two surveys[1] per season[2] at the project site (winter, spring, summer, fall) with two additional surveys during the local peak of shorebird abundance in Grays Harbor.	This option would provide a seasonal view of shorebird use and provide additional data during the critical shorebird use period.
2	15	One survey per month at the project site with three additional surveys during the local peak of shorebird abundance in Grays Harbor.	This option would capture more subtle changes in bird use of the area throughout the year, including gull and pelican migration in late summer, differing shorebird abundance through the wintering period, and capture information on fall migration.
3	20	Variable survey intervals designed to observe expected concentrated use periods, such as 5 surveys in mid-winter, 5 surveys during spring migration, 5 surveys in late summer, early fall and 5 surveys between these periods.	This option would provide a more concentrated view of known heavy use periods with some additional surveys at other times to capture any unknown or unexpected use of the site.
4a,b,c	20/30/40	Surveys as listed above in options 1-3 but with additional transects surveyed by a second observer at similar habitats near Point Brown in the Ocean Shores area.	These options would extend the surveys to the adjacent Ocean Shores peninsula to document use at similar habitats. Surveys may be able to document any displacement of birds due to construction at the project site.

[1]A "survey" is here defined as one day's sampling of the 4 transects (walking all 4 transects 3 times in one day during the three tide stages is a "survey").

[2]"Seasons" generally refer to winter, spring, summer, and fall seasons but adjusted for local conditions and known life history events of birds. Winter extends from November through March, spring from April through May, summer from June through August, and fall from September through October.

4.0 REFERENCES

Andres, B.A. and G.A. Falxa. 1995. Black Oystercatcher (*Haematopus bachmani*). In: *The Birds of North America*, No. 155 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 20 pp.

Bildstein, K.L., G. T. Bancroft, P.J. Dugan, D.H. Gordon, R.M. Erwin, E. Nol, L.X. Payne, and S.E. Senner. 1991. Approaches to the conservation of coastal wetlands in the western hemisphere. *Wilson Bulletin* 103:218-254.

Bradley, R.A. and D.W. Bradley. 1993. Wintering shorebirds increase after kelp (*Macrocystis*) recovery. *Condor* 95:372-376.

Brennan, L.A., J.B. Buchanan, S.G. Herman, and T.M. Johnson. 1985. Interhabitat movements of wintering dunlins in western Washington. *Murrelet* 66:11-16.

Brown, S., C. Hickey, B. Harrington, and R. Gill, eds. 2001. *The U.S. Shorebird Conservation Plan, 2nd ed.* Final Report. Manomet Center for Conservation Sciences, Manomet, MA. 61 pp.

Buchanan, J.B. 1992. Winter abundance of shorebirds at coastal beaches of Washington. *Washington Birds* 2:12-19.

Buchanan, J.B. 2000. *Shorebirds: Plovers, Oystercatchers, Avocets and Stilts, Sandpipers, Snipes, and Phalaropes*. Management Information Series. Washington Department of Fish and Wildlife, Volume IV:Birds. 48 pp.

Burger, J. 1981. The effect of human activity on birds at a coastal bay. *Biological Conservation* 21:231-241.

Burger, J. 1986. The effect of human activity on shorebirds in two coastal bays in northeastern United States. *Environmental Conservation* 13:123-130.

Burger, J. and M. Gochfeld. 1991. Human activity influence and diurnal and nocturnal foraging of sanderlings (*Calidris alba*). *Condor* 93:259-265.

Burton, N.K., P.R. Evans, and M. A. Robinson. 1996. Effects on shorebird numbers of disturbance, at the loss of a roost site and its replacement by an artificial island at Hartlepool, Cleveland. *Biological Conservation* 77:193-201.

Colwell, M.A. 1993. Shorebird community patterns in a seasonally dynamic estuary. *Condor* 95:104-113.

Colwell, M.A. and R.J. Cooper. 1993. Estimates of coastal shorebird abundance and the importance of multiple counts. *Journal of Field Ornithology* 64:293-412.

Colwell, M.A. and S.L. Landrum. 1993. Non-random shorebird distribution and fine-scale variation in prey abundance. *Condor* 95:94-103.

Connors, P.G., J.P. Myers, C.S.W. Connors, and F.A. Pitelka. 1981. Interhabitat movements by sanderlings in relation to foraging profitability and the tidal cycle. *Auk* 98:49-64.

Couch, A.B. 1966. Feeding ecology of four species of sandpipers in western Washington. M.S. Thesis. University of Washington, Seattle. 57 pp.

Frenkel, R.E. and L.M. Kunze. 1984. Introduction and spread of three Spartina species in the Pacific Northwest. *Association of American Geographers* 4:22-25.

Goss-Custard, J.D. 1977. The ecology of the wash. III. Density-related behaviour and the possible effects of a loss of feeding grounds on wading birds (*Charadrii*). *Journal of Applied Ecology* 14:721-739.

Handel, C.M. and R.E. Gill, Jr. 1992. Roosting behavior of premigratory dunlins (*Calidris alpina*). *Auk* 109:57-72.

Hartwick, E.B. 1976. Foraging strategy of the black oystercatcher (*Haematopus bachmani* Audubon). *Canadian Journal of Zoology* 54:142-155.

Herman, S.G. and J.B. Bulger. 1981. *The distribution and abundance of shorebirds during the 1981 spring migration at Grays Harbor, Washington.* U.S. Army Corps of Engineers, Contract report DACW67-81-M-0936. Seattle, Washington.

Holway, D.A. 1990. Patterns of winter shorebird occurrence in a San Francisco Bay salt marsh. *Western Birds* 21:51-64.

Howe, M.A., P. H. Geissler, and B.A. Harrington. 1989. Population trends of North American shorebirds based on the International Shorebird Survey. *Biological Conservation* 49:185-199.

Kalinowski, S.A., R.C. Martin, and L.D. Cooper. 1982. Wildlife studies on proposed disposal sites in Grays Harbor, Washington. Final Report by Washington State Department of Game, Aberdeen. 202 pp.

Klein, M.L., S.R. Humphrey, and H. F. Percival. 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. *Conservation Biology* 9:1454-1465.

Kyte, M.A. and M. Jordan. 1985. Marine plant, invertebrate, bird, and mammal resources and human activities off Willapa Bay, Washington. Unpublished Report prepared

for Shapiro and Associates by Ardea Enterprises. Vashon Island, WA. (cited in: BCI and Shapiro and Associates, Inc. 1991. Annotated bibliography: Chemical and biological literature inventory, Grays Harbor and Willapa Bay. Report to: U.S. Army Corps of Engineers, Seattle District. 64 pp.)

Lambeck, R.H.D., A.J.J. Sandee, and L. de Wolf. 1989. Long-term patterns in the wader usage of an intertidal flat in the Oosterschelde (SW Netherlands) and the impact of the closure of an adjacent estuary. *Journal of Applied Ecology* 26:419-431.

MacWhirter, B., P. Austin-Smith, Jr., and D. Kroodsma. 2002. Sanderling (*Calidris alba*). In: *The Birds of North America*, No. 653. (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 28 pp.

Marsh, C.P. 1986. Rocky intertidal community organization: the impact of avian predators on mussel recruitment. *Ecology* 67:771-786.

Mickelson, P.G., S.M. Murphy, J.S. Hawkings, and D.R. Herter. 1980. Evaluation of belt transects for censusing birds on the eastern Copper River Delta, Alaska. Pages 123-132 in F.L. Miller and A. Gunn (eds.), *Symposium on Census and Inventory Methods for Populations and Habitats*. Proceedings, Northwest Section, The Wildlife Society, Edmonton.

Ministry of Lands and Parks 1997. Standardized inventory methodologies for components of British Columbia's biodiversity: Shorebirds. Resource Inventory Branch, Terrestrial Ecosystem Task Force. Victoria, B.C. 61 pp.

Morse, R., S. Mlodinow, and W. Tweit. 2001. *A Birder's Guide to Coastal Washington*. R.W. Morse Co., Hoquiam. 270 pp.

Moser, M.E. 1987. A revision of population estimates for waders (*Charadrii*) wintering on the coastline of Britain. *Biological Conservation* 39:153-164.

Nettleship, D.N. 2000. Ruddy Turnstone (*Arenaria interpres*). In: *The Birds of North America*, No. 537 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 32 pp.

Page, G.W. and D.F. Whitacre. 1975. Raptor predation on wintering shorebirds. *Condor* 77:73-83.

Palmeirim, J.M. and J.E. Rabaça. 1994. A method to analyze and compensate for time-of-day effects on bird counts. *Journal of Field Ornithology* 65:17-26.

Paulson, D.R. 1993. *Shorebirds of the Pacific Northwest.* University of Washington Press, Seattle, Washington, USA.

Paulson, D.R. 1995. Black-bellied Plover (*Pluvialis squatarola*). In: *The Birds of North America*, No. 186 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 28 pp.

Pfister, C., B.A. Harrington, and M. Lavine. 1992. The impact of human disturbance on shorebirds at a migration staging area. *Biological Conservation* 60:115-126.

Quammen, M.L. 1982. Influence of subtle substrate differences on feeding by shorebirds on intertidal mud flats. *Marine Biology* 71:339-343.

Rehfisch, M.M. 1994. Man-made lagoons and how their attractiveness to waders mgiht be increased by manipulatin the biomass of an insect benthos. *Journal of Applied Ecology* 31:383-401.

Roberts, G. and P.R. Evans. 1993. Responses of foraging sanderlings to human approaches. *Behaviour* 126:147-159.

Senner, S.E., and F.J. McCaffery. 1997. Surfbird (*Aphriza virgata*). In: *The Birds of North America*, No. 266 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 20 pp.

Shields, W.M. 1977. The effect of time of day on avian census results. *Auk* 94:380-383.

Warnock, N.W. and R.E. Gill, Jr. 1996. Dunlin (*Calidris alpina*). In: *The Birds of North America*, No. 203 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 24 pp.

Warnock, N.W., and J.Y. Takekawa. 1995. Habitat preferences of wintering shorebirds in a temporally changing environment: western sandpipers in the San Francisco Bay estuary. *Auk* 112:920-930.

Wilcox, C.G. 1986. Shorebird and waterfowl use on restored and natural intertidal wetlands at upper Newport Bay, California. *Colonial Waterbirds* 9:218-226.

Wilson, W.H., Jr. 1991. The foraging ecology of migratory shorebirds in marine soft-sediment communities: the effects of episodic predation on prey populations. *American Zoologist* 31:840-848.

Wilson, W. H., Jr. 1993. Conservation of stop-over areas for migratory waders: Grays Harbor, Washington. *Wader Study Group Bull.* 67:37-40.

Wilson, W.H., Jr. 1994. Western Sandpiper (*Calidris mauri*). In: *The Birds of North America*, No. 90 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington D.C., 20 pp.